

LCA Methodology

Valuation Methods Within LCA - Where are the Values?

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Abstract

It is generally recognised that the valuation in LCA requires political, ideological and/or ethical values (hence the term). These values, however, are seldom discussed, and this paper may be seen as an early attempt. One result is that not only the valuation weighting factors, but also the choice of valuation methodology and the choice of using a valuation weighting method at all, are influenced by fundamental ethical and ideological valuations. Since there is no societal consensus on these fundamental values, and never will be one in an open democratic society, there is no reason to expect consensus either on valuation weighting factors, or on the valuation method or even on the choice of using a valuation weighting method at all. Another result of the discussion on values is that the ethical and ideological valuations are often made implicitly in the choice of method, data, etc., thus making it difficult to discuss the values and the implications of different standpoints. Although this paper focus on the valuation methods within LCA, it is expected that much of the discussion and the conclusions are of relevance for other environmental management tools, e.g. Environmental Impact Assessment.

Keywords: Environmental management tools; environmental impact assessment; ethical valuation, LCA; ideological valuation, LCA; LCA, methodology; Life Cycle Assessment (LCA); methodology, LCA; political valuation, LCA; valuation methods, LCA; values, political, ideological, ethical in LCA

1 Introduction

Within Life Cycle Impact Assessment, a distinction is generally made between the Classification/Characterisation on the one hand and the Valuation on the other hand (e.g. CONSOLI et al., 1993, HEIJUNGS et al., 1992, LINDFORS et al., 1995, UDO DE HAES, 1996). The reason for this distinction is the wish to separate parts of the impact assessment which can be analysed with more or less traditional natural sciences (i.e. the classification and the characterisation) from parts which also require other types of input (i.e. the valuation).

It is generally recognised that the valuation in LCA requires political, ideological and/or ethical values (hence the term). These values, however, are seldom discussed. An "ideology" consists of at least two aspects: a perception of the world as it is and ethical standpoints, i.e. ideas on how the world should be (e.g. HANSSON, 1981). The aim of this paper is to discuss some ideological standpoints that may influence the valuation in LCA. Although the focus is on valuation methods within LCA, it is expected that much of the discussion and the conclusions are also of relevance for other environmental management tools, e.g. Environmental Impact Assessment. This paper is a further elaboration of parts of a larger report (FINNVEDEN, 1996).

It is suggested that ideological standpoints can have an influence on at least three levels:

1. Should a weighting be performed at all or should some aspects be given absolute priority?
2. If a weighting is to be performed, which methodological approach should be chosen?
3. Given a certain methodological approach for weighting, which are the valuation weighting factors?

A zeroth level can also be distinguished. This is the level associated with whether or not an LCA is to be performed at all. By performing an LCA, it is implicitly assumed not only that the information it will produce is somehow useful but also that it should be used. This level, however, will not be discussed further here.

It should be noted that the discussion here will not be concerned with ideological differences in views on how important environmental issues are compared to other issues in society. In the valuation in an Environmental LCA, this is not of prime interest but, instead, the aspect of how different environmental features are valued against each other.

2 Weighting Methods or Not

Ethical theories can broadly be divided into two groups: deontological and teleological (e.g. FRANKENA, 1963). According to the teleological theories, the ethical value of an act is related to the consequences of the act. The ethically proper acts are those that produce the best consequences. According to utilitarianism (which is a teleological theory), it is the universal consequences that should be considered. Different schools have different opinions on what the "best" consequences are. For example, hedonistic utilitarianists consider consequences leading to the maximisation of pleasure over pain to be ethically good.

The deontological theories are not primarily related to the consequences of the acts. Other criteria must therefore be used. Examples of such criteria are authoritative rules such as God's 10 demands or the United Nation's declaration of human rights (ARIENSEN, 1993). An overview of international law of relevance for LCA has recently been published (VOLKWEIN and KLÖPPER, 1996). According to other deontological theories, the ethics are related to the procedure by which the normative rules are developed. If the procedure by which the rules are determined is ethically acceptable, then the rules will also be acceptable. One often cited example is "the theory of justice" developed by RAWLS (1973).

One important difference between the teleological and deontological theories is that according to the teleological theories, trade offs are possible, i.e. a weighting between different good and bad consequences is possible. According to the deontological group of theories, there will in general be rules which are given absolute priorities and trade-offs are therefore not possible.

This has a direct relevance for the discussion on valuation methods in LCA. For persons holding ethical beliefs in line with deontological theories, in which some rules are given absolute priority, methods involving weighting of different environmental problems against each other may seem unethical. Valuation methods involving weighting, are on the other hand, are in line with such teleological theories as utilitarianism.

Persons holding deontological ethics, however, may still accept a utilitarianistic approach for some type of decisions. For example, PRAWITZ (1990) argues that the maxim of maximising expected utility (which is in line with utilitarianism) is not acceptable when decisions are to be taken in which one alternative may lead to a negative outcome of catastrophic proportions. If this is not the case, expected utility may well be an acceptable decision criteria (*ibid.*). In relation to LCA, a reasonable standpoint for some people may thus be the concept that a weighting procedure may be acceptable as long as the LCA is concerned with small scale decisions involving only small changes. For larger decisions involving larger consequences, it may not be OK.

There are only a few valuation methods developed which do not involve a weighting procedure. PEDERSEN WEIDEMA, however, has developed two such methods for LCA.

In the first (PEDERSEN, 1991), an absolute priority is given to irreversible use of non-renewable resources which also by themselves are not comparable.

The second involves a further development of Rawls' "Theory of justice" (PEDERSEN, 1992) in which an absolute priority is given to effects on working conditions, human health and violation of human, animal and/or natural rights.

Case-specific valuation procedures, e.g. a "verbal-argumentative approach" (SCHMITZ et al., 1994), result in case-specific results (rules) which may be in line with the group of deontological theories that focus on the procedure. Persons holding such ethics may thus accept case-specific valuation methods, provided that the procedures by which they are developed are acceptable.

All quantitative valuation methods developed in connection to LCA involve a weighting procedure (see, for example, BRAUNTSCHWEIG et al., 1994, FINNVEDEN, 1996, GIEGRICH et al. 1995, HOFSTETTER, 1996, LINDEIJER, 1996, and LINDFORS et al., 1995 for recent reviews). It may be argued that a weighting procedure has been accepted implicitly already by making the decision to perform a full LCA. This is because if some aspects were given absolute priorities, it would normally be enough to consider these aspects and needless to perform a full LCA (HEIJUNGS et al., 1992). Single-indicator methods based on mass displacement (SCHMIDT-BLEEK, 1993) or energy requirements, for example, can possibly be seen as valuation methods, without weighting, focussing on a specific parameter. LCAs, however, will include several types of parameters in most cases. The rest of this paper will therefore concentrate on valuation methods including weighting procedures.

Although utilitarianism is much debated and controversial (e.g. SMART and WILLIAMS, 1973), expected utility as a decision criteria is the major paradigm in decision theory both in descriptive and normative applications (HANSSON, 1991). It is sometimes suggested to be the "objective" decision criteria which in relation to this discussion can be seen as a clearly normative standpoint.

3 The Weighting Method

The choice of a weighting method may also be influenced by ideological and ethical standpoints. Here, three aspects will be discussed: views on the society, ethical views and views on nature.

3.1 Views on the society

The preferred weighting method, and aspects of the weighting method, may depend on views of the society and ideological standpoints. Much of the political debate during the 20th century has centred around views of the societal economy and representative democracy. These issues may also reflect choices concerning weighting methods in LCA.

3.1.1 Views on market economy

For people holding a positive view of the market economy as a system for exchanging information, it may be reasonable to advocate weighting methods which make use of market prices and other types of information derived from the market. Such methods will typically result in weighting factors expressed in monetary units. However, as discussed below, all methods using monetary units will not be based on values derived from a market. For persons holding a negative view of the market economy, information from the market is more or less useless. Persons with such views would probably not advocate a method based on market information. A conditional view of the market economy suggesting that some information can be derived from the market in some cases, is a frequently encountered standpoint in many western European countries.

A positive view of the market economy is often, but not necessarily, accompanied with a standpoint that there are only values related to individuals. The values of a society is just the sum of the values of the individuals in the society. If we are interested in the values of the society we must therefore evaluate this from the values of individuals. For people holding a positive view on market economy, it is reasonable to assume that people's values are expressed in the market, and can therefore be deduced from the market.

3.1.2 Views on representative democracy

If it is assumed that decisions taken by democratically elected governments will represent the views of a society, and that valuation weighting factors should reflect these views, the weighting methods may ideally use information derived from governmental decisions. These types of methods may also result in weighting factors expressed in monetary units, if the weighting factors are derived in such units. Some of the so called distance-to-target methods are based on governmental decisions. The appropriateness of straight distance-to-target methods as valuation weighting methods, however, has been questioned for other reasons (e.g. FINNVEDEN, 1996). For persons holding a less positive view of representative democracy, decisions taken by governments may be less representative of the views of the society.

3.1.3 Views on Platonic philosophers/experts

Plato did not believe in democracy. He thought that if societies were ruled by philosophers/experts, better decisions would be made. People subscribing to a similar view may suggest that difficult decisions should be taken by experts and not by common people or their representatives. For people holding these views, it seems reasonable that weighting factors may be derived from the opinions of experts. For other people, this view is undemocratic. They would perhaps suggest that there is a role for experts in providing the basis for decisions, although there is no special role for experts when ideological decisions are taken into account.

Weighting factors derived from a panel of "Platonic experts" only representing themselves would then not be authoritative. (Such a panel, however, should not be mixed with a panel consisting of representatives from different stakeholder groups. Such a panel may also be called an "expert panel", especially if different stakeholders choose to be represented by "experts". However, from a democratic standpoint, such a panel may be representative and thus authoritative for some people).

3.2 Ethical views

Something that is valuable, may either have an instrumental value or an intrinsic value to somebody. If something has an instrumental value, it is valuable because it can be used in order to gain something that has an intrinsic value. Something that has an intrinsic value is valuable in itself. Both instrumental and intrinsic values are valuable in relation to somebody or something performing the valuation. If this "somebody or something" performing the valuation has an ethical value we may call this "somebody or something" a moral object (ARIANSEN, 1993). If we are following a universal moral, we have ethical obligations towards moral objects, at least to some extent. It is generally accepted that living people are moral objects. One interesting question however, is whether the class of moral objects should be expanded beyond that. Another important question is what relative importance different moral objects should be given.

3.2.1 Are all living people equally important?

A positive answer is in line with the United Nation's declaration of human rights, for example, and it is a principle which is generally accepted in most liberal democracies. However, people and governments may not always act according to this principle. If weighting factors are derived from the behaviour of people or governments, weighting factors may thus be in conflict with the principle. Also, if willingness-to-pay measures are used without income adjustments, the resulting weighting factors may violate the principle. This is because the possibility to pay varies with income.

3.2.2 Are future people moral objects, and if so, how important are they?

This question has a direct consequence on the methodological question of how to handle future impacts in an LCA. Should future impacts occurring after a certain time period be cut-off and neglected? Should some sort of discounting be used?

A cut-off is consistent with a view that future people are not moral objects. The purpose of discounting is to discriminate against the future (TURNER et al., 1994). However, there may be different reasons behind this. A discount rate is often described as consisting of two parts.

1. The pure time preference of the present generation. If impacts in the future are valued less importantly than impacts occurring today, simply because they are occurring in the future, the time preference is larger than zero. A time preference of zero is consistent with a view that future impacts are as important as today's.

2. The other part of the discount rate consists of a function of growth of real consumption and the elasticity of the marginal utility of consumption (TURNER *et al.*, 1994). Often, the growth is assumed to be exponential. However, if the capacity of growth is limited, a logistic growth may be more realistic resulting in a dynamic and very different discount rate (STERNER, 1994). A positive discount rate may thus be consistent with a view that future people are moral objects with the same relative importance as current people. In conclusion, the choice of a discount rate is an ideological issue, both in relation to the ethical question on time preferences, and in relation to the expected growth in the future. Views on discount rates are also likely to be affected by views on the market economy since the rate may be seen as the market price for capital.

In most currently available LCA valuation methods, these questions are not addressed explicitly. This is the case, for example, if weighting factors are used in which an integration over time has already been performed. For example, if a weighting factor is derived from a governmental decision on emission targets, already in the decision stage, an integration over time has been performed. The discount rate, or the cut-off, is then the same as was implicitly used when the decision was made. Although the ideological choices in these cases are implicit, and not well described, they are nevertheless present.

A decision on cut-off or discount rates, however, is necessary if the ambition in the impact assessment is to describe the damages done by different interventions (*i.e.* emissions or resource use), followed by a valuation of the damage. In the EPS-system (STEEN and RYDING, 1992), this is partly the case. No discount rates are used, instead the valuation is performed by integrating over a chosen time-frame. This time-frame varies for different types of impacts (FINNVEDEN, 1996).

If future people are to be considered as moral objects, one problem comes from the fact that it is only current people that can be involved in the actual weighting. In the weighting method, there may thus be a need for some formal procedure to secure that the values of future generations are not neglected, to the extent that these are foreseeable.

3.2.3 Are animals, plants, and/or ecosystems also moral objects?

This is of course a fundamental ethical question in which different opinions may be encountered in society. If the answer to any of the questions is yes, this may have some consequences for the weighting method. In this case, there may also be a need for some formal procedure to secure that the values of all moral objects are considered to the extent that we can understand these values.

3.2.4 Are equality and justice of importance?

Environmental risks are not distributed evenly across populations (HARDING and HOLDREN, 1993). Low-income groups frequently receive disproportionate shares of environmental hazards. The question of justice is related to what is considered "proportionate" shares (also proportionate in relation to what?). Important ideological questions are then, what is the just distribution and how important is it that it is fulfilled? When discussing life cycle valuation methodology, these questions may be summarised as: Does it matter who is affected by the environmental impacts? In currently available weighting methods, no consideration is given to these questions. Thus, in practice, environmental justice is not given any consideration.

It may be argued that equality and justice are aspects that are difficult to handle in a Life Cycle Impact Assessment. This is because it is in general not possible to handle site-specific aspects (*e.g.* UDO DE HAES, 1996). However, in a generic site-dependent approach, questions related to equality and justice could possibly be included. To be able to handle these questions, a further development of LCA in general may therefore be required.

3.3 Views on nature

3.3.1 To what extent are we able to predict environmental impacts?

The answer to this question is dependent on our views on nature. Nature may, for example, be seen as benign or surprising (WIMAN, 1990). A benign nature will respond when exposed to stress, so that nature will adjust itself to the former state of behaviour if the stress is lessened or removed. A surprising nature may hide the response when exposed to stress and at some time flip to another state in a more or less irreversible manner. Our possibilities to predict environmental impacts will be larger if nature is benign rather than surprising.

These questions are also linked to the precautionary principle and its application. Assuming a benign nature, the precautionary principle may be seen as unscientific and unnecessary. Assuming a surprising nature, the precautionary principle is probably necessary.

The answers to the question in the heading will also influence the choice of methodology for deriving weighting factors in valuation methods. If we are generally able to predict environmental impacts, it may be of interest to look for valuation methods in which the environmental damages are predicted and valued. If, however, we are primarily unable to predict environmental impacts, it is reasonable to look for valuation methods in which it is not necessary to evaluate the environmental damages since this will be impossible to a large extent.

This discussion also has a bearing on the methodology for the classification/characterisation and its relation to the

valuation. Consider the cause-effect chain of environmental problems (FINNVEDEN et al., 1992). In the beginning, the interventions occur, i.e. the emissions to the environment and the use of resources. In an LCA, these data are documented in the inventory. In the later parts of the cause-effect chain, the intrinsic values are present, i.e. the values we want to protect. In the classification, inputs and outputs are assigned to different impact categories. There has been a considerable amount of discussions concerning which impact categories to consider and different lists have been suggested (e.g. CONSOLI et al., 1993, HEIJUNGS et al., 1992, LINDFORS et al., 1995, UDO DE HAES, 1996). Despite the discussions, the different lists have many aspects in common. One such aspect is that the impacts are often defined quite early in the cause-effect chain. Thus, many of the impact categories are more related to negative instrumental values than intrinsic values. These impacts may be called "environmental threats" since they are threatening the intrinsic values. The "areas for protection" (as discussed for example by CONSOLI et al., 1993 and UDO DE HAES, 1996) may either be intrinsic values or instrumental values close to these intrinsic values.

The choice of the intrinsic values and the comparison between them are both ethical and ideological choices. The relationships between an emission and the potential impacts, are in principle questions to be answered by natural sciences, whether the impacts are defined on the level of "environmental threats" or on the level of "areas for protection". Thus, in going from inventory data to a valuation, both natural science based information and valuations must be considered. From a methodological standpoint, the interesting questions are now:

- ♦ What type of information should be valued?
- ♦ Where in the cause-effect chain should the classification/characterisation be placed?
- ♦ Should the valuation be based on data from the inventory analysis, on an "environmental threat"-based classification/characterisation or on an "area for protection"-based classification/characterisation?

The answers to the questions above will depend on the answer to the question: To what extent are we able to predict environmental impacts? Persons with a positive view on our abilities to predict environmental impacts will perhaps suggest that the valuation is performed on information from a classification/characterisation close to the intrinsic values. Such persons would thus ask for information on the level of damages rather than threats. On the other hand, persons with a less positive view, perhaps emphasising the precautionary principle, will suggest that the valuation is performed on information from a classification/characterisation earlier in the cause-effect chain.

Our abilities to predict environmental impacts will also vary with different impacts. For impacts like acidification and eutrophication which have been known environmental problems for decades, and for which there is a lot of available information (although there are data gaps as well), predic-

tions may be possible. If, on the other hand, the focus is on new chemicals for which only a few physico-chemical data is available, it is difficult, if not impossible, to predict the environmental impacts.

4 The Weighting Factors

After a weighting method has been chosen, the weights themselves will also be influenced by ideologies. Below, some aspects will be discussed briefly. Some of these were already mentioned above as ideological views on the weighting methods.

4.1 Views on market economy

For persons holding a positive view on market economies, environmental assets which already have a place on the market are likely to be valued as being less important. An example could be non-renewable resources which some people argue is not a problem. This may be done from the viewpoint that the market will see that new resources are developed when needed (e.g. DASGUPTA, 1989).

Also, a positive view on market economy may suggest that market derived discount rates are used, resulting in less weight to impacts occurring in the future. For persons with these views, a concentration on impacts occurring in the near future, with external effects which the market will not handle, is probably of more relevance.

4.2 Are future people moral objects and if so, how important are they?

Views on the importance of future people will influence the weighting of impacts in the distant future compared to impacts in the near future.

4.3 Are animals, plants, and/or ecosystems also moral objects?

Animals, plants and ecosystems have an instrumental value for humans. If they also have an intrinsic or inherent value, it is likely that impacts on them are weighted more heavily than if only the instrumental value is considered.

4.4 To what extent are we able to predict environmental impacts?

Persons holding a more negative view on our possibilities to predict environmental impacts are likely to stress the importance on the precautionary principle. They will probably give a greater weight to impacts where larger uncertainties prevail compared to more well studied impacts. Examples of impacts with larger uncertainties are impacts occurring in the distant future, impacts from less studied chemicals, impacts on biodiversity, and impacts occurring fast compared to the response times of nature and society.

4.5 What is the importance of the natural systems in relation to the economic systems?

The overall economic system is an open subsystem of the overall ecosystem (FOLKE, 1990). Economic systems use ecosystems as sources for energy and natural resources, and as sinks for waste. The economic systems are also dependent on a number of environmental services provided by the ecosystems. Different persons may have opposing views on how important the overall ecosystem is for the overall economic system. Persons emphasising the importance of the ecosystem are likely to weigh impacts on ecosystems and their functioning more heavily.

4.6 What is the long-term development of natural systems?

Two extreme positions may be taken in relation to this question (WANDÉN, 1993). According to the first position, nature will develop into a climax situation. According to the second position, nature will always change and develop, and it is not possible to compare different situations.

1. The first position is often accompanied by a valuation of the climax situation as something intrinsically valuable. Man should try to avoid disturbing nature in order to let the climax situation be developed.

2. The second position is often accompanied by a standpoint that, since different situations cannot be compared, there is no intrinsic difference between systems influenced by man and those which are not.

Persons taking the first position are likely to value **undisturbed ecosystems and biological diversity** more than persons taking the second position.

5 Conclusions

Although seldom discussed in relation to LCA, values including ethics, morals and ideology are involved in the valuation. This paper may be seen as an early attempt at dealing with this subject. One result is that not only the valuation weighting factors, but also the choice of valuation methodology and the choice of using a valuation weighting method at all are influenced by fundamental ethical and ideological valuations. Since there is no societal consensus on these fundamental values, and never will be in an open democratic society, there is no reason to expect consensus either on valuation weighting factors, or on the valuation method, or even on the choice of using a valuation weighting method at all. It can therefore be expected that several approaches for valuation will develop including several different weighting sets. The construction of several lifestyle-dependent weights by the use of a cultural perspective has also been suggested in a recent report (HOFSTETTER, 1996).

Another result of the discussion on values is that the ethical and ideological valuations are often made implicitly in the choice of method, data, etc. Thus, the value-related decisions are only rarely taken explicitly in the development of

the methods and the data. As long as the valuations are made implicitly, and almost subconsciously, it will be difficult to discuss the values and the implications of different standpoints. A prerequisite for an increased agreement on valuation methods may be that ethical and ideological values of relevance are discussed more explicitly.

Although the focus of this paper has been on valuation within LCA, most of the discussion and the conclusions are generic and, thus, will also be of relevance also for other environmental management tools.

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6 References

- ARIANSEN, P. (1992): Environmental philosophy (Miljöfilosofi), Universitetsforlaget (In Norwegian). (In Swedish translation (1993): Miljöfilosofi, Nya Doxa, Nora)
- BRAUNSCHWEIG, A.; FÖRSTER, R.; HOFSTETTER, P.; MÜLLER-WENK, R. (1994): Evaluation und Weiterentwicklung von Bewertungsmethoden für Ökobilanzen - Erste Ergebnisse. IWÖ-Diskussionsbeitrag Nr.19. IWÖ, Hochschule St. Gallen, St. Gallen, Switzerland. (Partly in German)
- CONSOLI, F.; ALLEN, D.; BOUSTEAD, I.; FAVA, J.; FRANKLIN, W.; JENSEN, A.A.; DE OUDE, N.; PARRISH, R.; PERRIMAN, R.; POSTLETHWAITE, D.; QUAY, B.; SÉGUIN, J.; VIGON, B. (Eds) (1993): "Guidelines for Life-Cycle Assessment: 'A Code of Practise'"; SETAC; Brussels, Belgium
- DASGUPTA, P. (1989): Exhaustible resources. In Friday, L. and Laskey, R. (eds.): The fragile environment. 107-126. Cambridge University Press
- FINNVEDEN, G.; ANDERSSON-SKÖLD, Y.; SAMUELSSON, M.-O.; ZETTERBERG, L.; LINDFORS, L.-G. (1992): Classification (Impact Analysis) in Connection with Life Cycle Assessments - A Preliminary Study. In "Product Life Cycle Assessments - Principles and Methodology", Nord 1992:9, 172-231, Nordic Council of Ministers, Copenhagen, Denmark
- FINNVEDEN, G. (1996): Valuation methods within the framework of Life Cycle Assessment. IVL Report No B 1231, IVL, Stockholm, Sweden
- FOLKE, C. (1990): Evaluation of Ecosystem Life-Support in relation to Salmon and Wetland Exploitation. Dissertation. Department of Systems Ecology, Stockholm University, Stockholm, Sweden
- FRANKENA, W. (1963): Ethics. Prentice-Hall. (In Swedish translation: Etik, Studentlitteratur, Malmö)

- GIEGRICH, J.; MAMPEL, U.; DUSCHA, M.; ZAZCYK, R.; OSORIO-PETERS, S.; SCHMIDT, T. (1995): Bilanzbewertung in produktbezogenen Ökobilanzen. Evaluation von Bewertungsmethoden, Perspektiven. In "Methodik der produktbezogenen Ökobilanzen – Wirkungsbilanz und Bewertung". Texte 23/95. Umweltbundesamt, Berlin, Germany. (In German)
- HANSSON, S. (1981): Modern ideologies, nine lectures. (Moderna ideologier, nio föreläsningar). Liber förlag. (In Swedish)
- HANSSON, S.O. (1991): The burden of proof in toxicology. Report 9/91. The Swedish National Chemicals Inspectorate, Solna, Sweden
- HARDING, A.K.; HOLDREN, G.R.Jr. (1993): Environmental equity and the environmental professional. Environ. Sci. Technol., 27, 1990-1993
- HEIJUNGS, R.; GUINÉE, J.B.; HUPPES, G.; LANKREIJER, R.M.; UDO DE HAES, H.A.; WEGENER SLEESWIJK, A.; ANSEMS, A.M.M.; EGGELS, P.G.; VAN DUIN, R.; GOEDE, H.P. (1992): Environmental Life-Cycle Assessment of Products. Guide and Backgrounds. CML, Leiden University, Leiden, The Netherlands
- HOFSTETTER, P. (1996): Towards a structured aggregation procedure. In Braunschweig, A., Förster, R., Hofstetter, P. and Müller-Wenk, R.: Developments in LCA Valuation, 123-211. IWÖ - Diskussionsbeitrag Nr. 32. IWÖ, Hochschule St. Gallen, St Gallen, Switzerland
- LINDEIJER, E. (1996): Normalisation and valuation. In Udo de Haes, H.A. (Ed.): Towards a Methodology for Life Cycle Impact Assessment, 75-93. SETAC-Europe, Brussels, Belgium
- LINFORS, L.-G.; CHRISTIANSEN, K.; HOFFMAN, L.; VIRTANEN, Y.; JUNTILLA, V.; HANSEN, O.-J.; RÖNNING, A.; EKVALL, T.; FINNVEDEN, G. (1995): 'Nordic Guideline on Life-Cycle Assessment'. Nord 1995:20; Nordic Council of Ministers, Copenhagen, Denmark
- PEDERSEN, B. (1991): Hvad er et bæredygtigt ressourceforbrug. Tværfagligt center, Danmarks Tekniske Højskole, Lyngby. (In Danish)
- PEDERSEN, B. (1992): Udvikling af kvalitetsstandarder for forarbejdede økologiske fødevarer. Tværfagligt center, Danmarks Tekniske Højskole, Lyngby. As cited in Pedersen Weidema (1993): Evaluation methods for product life cycle assessment. Part F of "Development of a method for product life cycle assessment, with special reference to food products". Dissertation, Tværfagligt center, Danmarks Tekniske Højskole, Lyngby, Denmark
- PRAWITZ, D. (1990): Att överleva eller att må väl: Om olika mål för miljövård. In Lundgren, L.J. (Ed.): Vad tål naturen. Rapport 3738. Naturvårdsverket, Solna. (In Swedish)
- RAWLS, J. (1973): A theory of justice. Oxford University Press
- SCHMIDT-BLEEK, F. (1993): MIPS re-visited. Fresenius Environmental Bulletin, 2, 407-412
- SCHMITZ, S.; OELS, H.-J.; TIEDEMANN, A., et al. (1994): Eco-balance for Drink Packaging. Comparative Investigation of the Environmental Effects of the various Packaging Systems for Fresh milk and Beer. German Federal Environmental Office, III 2.5. Revised Editions, June 7
- SMART, J.J.C.; WILLIAMS, B. (1973): Utilitarianism, for and against. Cambridge University Press
- STEEN, B.; RYDING, S.-O. (1992): The EPS enviro-accounting method. An application of environmental accounting principles for evaluation and valuation of environmental impact in product design. IVL Report B 1080. IVL, Göteborg, Sweden
- STERNER, T. (1994): Discounting in a world of limited growth. Environmental and Resource Economics, 4, 527-534
- TURNER, R.K.; PEARCE, D.; BATEMAN, I. (1994): Environmental economics, an elementary introduction. Harvester Wheatsheaf
- UDO DE HAES, H.A. (1996): Discussion of general principles and guidelines for practical use. In Udo de Haes, H.A. (Ed.): Towards a Methodology for Life Cycle Impact Assessment, 7-30. SETAC-Europe, Brussels, Belgium
- WANDÉN, S. (1993): Ideological controversies in environmental protection. (Ideologiska kontroverser i miljövården.) Rapport 4196. Naturvårdsverket, Solna, Sweden. (In Swedish)
- WIMAN, I.M.B. (1990): Expecting the Unexpected: Some Ancient Roots to Current Perceptions of Nature. Ambio, 19, 62-69
- VOLKWEIN, S.; KLÖPPER, W. (1996): The Valuation Step within LCA. Part I: General principles. Int. J. LCA, 1, 36-39

The Valuation Step Within LCA

Part I: General Principles

STEPHAN VOLKWEIN, WALTER KLÖPPER (Int. J. LCA 1/1, 36-39, 1996)

Some basic principles required for the development of a valuation procedure in life cycle assessment are described. International **human rights** conventions and international **environmental** laws and conventions are analyzed for the usefulness in obtaining general principles for the valuation step of life cycle assessment. The human right to the enjoyment of the highest attainable standard of physical and mental health, the conventions of the Earth Summit in Rio 1992, the Montreal Protocol on Substances that Deplete the Ozone Layer 1987, and other treaties and conventions are shown to be a suitable basis for the valuation.

Part II: A Formalized Method of Prioritization by Expert Panels

STEPHAN VOLKWEIN, REGINE GHR, WALTER KLÖPPER (Int. J. LCA 1/4, 182-192, 1996)

International **human rights** conventions and international **environmental** laws and conventions have been used to deduce criteria for a valuation procedure in life cycle assessment. The valuation procedure relates to the impact oriented assessment of the Centrum voor Milieukunde in Leiden (CML). The panel method is suitable for comparing LCAs of two systems, or for optimizing LCAs. The method consists of four steps:

Step one is the normalization of the results of the impact assessment. In *step two*, a panel of experts values the results by three qualitative criteria (time, space, hazard). In *step three*, a ranking diagram technique is used for a formalized priority setting and a preliminary identification of the product causing the most environmental burdens. *Step four* includes a sensitivity analysis and a plausibility check based on an energy and waste analysis. Discrepancies between the plausibility check and step three may cause a re-evaluation of parts of the valuation, impact assessment, inventory table or goal definition of the LCA.